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FOREST PEST MANAGEMENT

3430 BIOLOGICAL EVALUATION
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INCIDENCE OF ROOT DISEASES AND DWARF MISTLETOE IN MOUNTAIN PINE BEETLE KILLED PONDEROSA PINE IN THE COLORADO FRONT RANGE

United States Department of Agriculture
Forest Service
Forest Pest Management
Denver, Colorado

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INTRODUCTION

The mountain pine beetle (*Dendroctonus ponderosae* Hopkins) has caused considerable mortality to ponderosa pines (*Pinus ponderosa* Laws) in the Front Range of Colorado. Since 1976 Forest Pest Management in Region 2 has conducted extensive-type surveys to evaluate survey techniques and impact caused by this insect (1, 2, 3, 4). The sole objective of these surveys was to measure the presence or absence of insect activity on killed pines.

Armillaria root rot, caused by *Armillariella mellea* (Vahl.:Fr.) Karst., is the most prevalent root pathogen in Region 2. This pathogen is capable of killing all species of conifers found in this region. However, no current data exists on numbers of trees killed, location, volume, or number of acres infected by this pathogen.

Ponderosa pine dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum* (Engelm.) Hawksworth & Wiens) can be a serious pathogen on ponderosa pine (5). Currently, in Colorado, approximately 20% of the ponderosa pine type is infected by dwarf mistletoe (personal communication, Dave Johnson, FPM, R-2).

There is growing scientific literature documenting the predisposition of diseased trees to insect attack. Rudinsky's 1962 (6) review of the family Scolytidae suggests that bark beetles breed mainly in "physiologically sub-normal" (stressed) trees and are therefore secondary agents. Cobb *et al.* (7) states there is a high degree of association in ponderosa pine and white fir (*Abies concolor* (Gord. and Glend.) Lindle.) between root diseases and infestation by bark beetles. Other studies show that up to 80% of bark beetle infested ponderosa pines were infected by root disease fungi prior to beetle attack, whereas none of an equal number of non-infested trees were infected (8). Herbert *et al.* (9) reported that 96% of bark beetle attacked grand fir also had root disease.

Dwarf mistletoe and the needle pathogen *Elytroderma deformans* (Weir) Darker, have also been associated with increased bark beetle activity (10, 11, 13).

All surveys conducted to date for mountain pine beetle in R-2 have ignored diseases, regardless of their potential killing and predisposing aspects.

This biological evaluation was conducted to test the assumption that all ponderosa pine mortality seen on aerial photography is attributed to mountain pine beetle during epidemic insect cycles.

METHODS AND MATERIALS

In the summer of 1980, Lockheed Engineering and Management Services Company, Inc. was contracted to evaluate the use and value of high altitude panoramic aerial photography for obtaining FIDIS (Forest Insect and Disease Information System, FSH 3453) inputs on the annual mortality of ponderosa pine caused by mountain pine beetle. Lockheed was contracted to acquire photography, conduct photointerpretation, establish ground verification, and write a final report (12).

A total of 1,105 photo frames were collected and interpreted for current mortality. The 1,105 photos contained 5,657,600 potential ground verification plots. Only 80 ground verification plots were selected for the mountain pine beetle study (see (12) for selection methods).

For this study, a random sample of 9 of the 80 original ground plots were selected (a 11 % sample) (Table 1). The 9 selected plots were revisited during August 1981.

All dead trees on the plots were visited and incidence of *A. mellea* and dwarf mistletoe noted. Since the plot borders were originally marked with string there was little chance to miscount mortality trees. If doubt existed on accuracy of border locations, the original film with overlays, was used to assist in re-establishment.

RESULTS

A total of 175 trees on 9 five acre ground truth plots were examined (Table 2). Of the 175 trees examined 54.9% had only *A. mellea* and beetles, 6.9% had only dwarf mistletoe and beetles, and 6.9% had *A. mellea*, dwarf mistletoe, and beetles. In summary, 68.7% of all dead trees had either *A. mellea*, dwarf mistletoe, or both.

CONCLUSIONS

While it is convenient and expedient to assume all mortality seen on aerial photography is caused by one agent it is not a biologically sound assumption. This evaluation establishes the fact that diseases are associated with the majority of successful mountain pine beetle attacks during an epidemic beetle cycle. Therefore, to ignore these interactions in future surveys will make the resulting data subject to major error.

Future mortality surveys must adequately address the area of insect/disease interactions by recording all damaging agents present. This will allow adequate assessment of pest damage and allow properly programmed control.

How can the problem of insect and disease interactions be adequately addressed? The criteria used in designing the survey, including photo interpretation guides, must be critically designed and executed. Two basic approaches seem most appropriate. The first approach could be to count just

TABLE 2: Incidence of root disease and dwarf mistletoe in ponderosa pine assumed to be killed by mountain pine beetle.

Photo Plot Number	Number Trees Assumed Killed By MPB	Number Trees With Root Diseases Only	Number Trees With Dwarf Mistletoe Only	Number With Both
240-4	1	1	-	-
250-1	32	18	-	-
254-3	51	24	10	5
1174-1	13	8	-	-
1230-2	20	8	2	7
1242-2	8	7	-	-
1248-1	4	4	-	-
1374-2	27	18	-	-
1416-1	19	8	-	-
Totals	175	96	12	12
Percent of Total	100	54.9	6.9	6.9

Percent with root disease is 54.9 + 6.9 = 61.8

Percent with pathological problem is 54.9 + 6.9 + 6.9 = 68.7

Percent with MPB only = 31.3

dead trees from the aerial photographs. When ground truthing, the photography crews should note all pests associated with the mortality. This data would then be used to assign proportions of the total mortality to the proportion of occurrence of each pest or pest complex. The other approach could be to partition the mortality observed on each photography to a causal pest category. This latter approach assumes that adequate photographic signatures exist for each pest. For mountain pine beetle and root diseases in the Rocky Mountain Region, photography signatures are too similar to aid in their separation. Root diseases in the ponderosa pine type occur as single scattered trees to groups of 3-5 trees and resembles endemic mortality caused by bark beetles. Seldom do root diseases in this region cause large stand openings where mortality has occurred over a period of many years as is seen in the northwestern areas of the United States.

This lack of definitive photographic signatures for most bark beetles and root diseases means that separating them, except on the ground, is very nearly impossible.

If these observations are accepted as stated, then in the Rocky Mountain Region aerial surveys must have the mortality causes separated by ground truthing.

How, then, is it decided if a tree was killed by bark beetles or root disease? In the case of mountain pine beetle and *A. mellea* in the Rocky Mountain Region this problem can be handled in one of two ways. First, if mountain pine beetle and *A. mellea* occur on the same tree, that tree can be categorized as mortality caused by a complex of pests. Secondly, if it is necessary to attribute the mortality to a single pest then the following observations will lead to a conclusion:

1. If *A. mellea* is found beyond 1' from the root collar zone on only one lateral root then the tree was killed bark beetles.

2. If *A. mellea* is found closer than 1 foot and on more than one lateral root, the tree was being stressed by the disease and the bark beetles only killed the tree before the disease did. Tally as a root disease tree.

3. If *A. mellea* is found at the root collar, tally as a root disease tree.

Armillaria root rot is capable of attacking trees both as a saprophyte and a parasite. Saprophytic attacks cannot be tallied as root disease-caused mortality. To determine the mode of attack, check the advancing margin of infection for resinosis. Resinosis indicates active resistance of the tree to attack. If no resinosis is present the tree is probably being colonized saprophytically. The preceeding diagnosis of mode of attack must be tempered with good judgment since not all parasitic attacks produce resinosis; whereas, all saprophytic attacks are devoid of resinosis.

TABLE 1 - SUMMARY OF PHOTOGRAPHIC AND GROUND COUNTS

Photographic survey									Ground survey	
Stage 1			Stage 2			Stage 3				
Selected PSU number	Count	Quick counts	Total faders per PSU	Selected SSU number	Faders in selected SSU	Total faders per SSU	Selected TSU number	Faders in selected TSU	Ground counts	Volume, cu ft
140	1	1	28	3-21	19	0	-	-	-	0*
240	1	16	2	3-24	1	2	E-1	1	0	0
	2		3	3-28	2	3	A-1	2	4	32.902
	3		28	1-22	6	11	D-1	8	0	0
	4		9	2-24	4	5	E-2	1	1	28.221
250	1	13	520	4-22	55	44	D-1	20	32	293.319
254	1	35	793	2-25	97	245	B-1	57	97	1133.378
	2		795	4-25	222	590	A-2	22	21	412.171
	3		1179	4-25	363	533	D-1	25	51	633.822
256	1	69	1025	2-24	156	253	E-3	19	27†	372.11†
	2		1607	1-24	408	590	B-1	58	69	1130.868
262	1	16	165	2-22	17	47	B-1	21	40	284.920
332	1	35	157	2-20	42	25	D-1	3	0	0
366	1	7	56	2-28	39	3	B-3	3	0	0
	2		168	3-27	20	0	-	-	-	0*
456	1	12	214	4-21	25	24	H-3	13	0	0
558	1	20	200	4-37	55	49	C-1	39	86	1524.808
564	1	17	450	1-38	103	161	D-3	48	103	2037.999
566	1	35	153	3-32	37	32	H-2	3	0	0
1052	1	34	94	1-10	31	47	H-2	6	6	167.039
1058	1	40	1084	1-6	33	42	C-2	22	66	354.980
	2		1689	2-5	90	54	G-4	33	119	1120.961
	3		1680	3-12	124	145	A-2	69	96	801.698
1100	1	11	46	3-16	9	10	B-4	8	7	109.371
1104	1	15	59	4-14	13	10	C-2	6	6	59.776
1122	1	5	26	3-34	8	4	B-2	3	0	0
1128	1	14	38	3-37	29	39	E-3	21	51	693.864
1152	1	45	985	3-22	53	66	H-4	26	40	192.632
	2		709	4-13	77	117	D-1	17	27	309.545
	3		807	4-18	30	37	A-1	36	34	641.136
1154	1	34	642	1-18	57	45	D-4	33	31	267.938
1156	1	31	839	4-11	77	87	B-4	13	29	409.337
	2		988	3-20	161	158	H-3	18	19	233.906
1162	1	30	1048	4-21	202	236	F-1	25	25	178.453
	2		1701	3-14	80	117	D-1	9	8	119.800
1164	1	13	505	3-31	128	136	A-3	36	47	825.625
1174	1	9	33	4-10	11	21	F-2	8	13	89.934
1198	1	13	89	4-18	18	20	B-2	2	3	36.138
1210	1	48	138	4-28	25	28	G-1	11	0	0
	2		66	3-26	7	6	C-4	3	3	57.807
	3		116	2-28	33	29	C-3	2	2	35.834
	4		125	3-27	7	27	C-1	9	12	192.364
1228	1	9	381	4-16	162	250	E-1	92	163	809.612
	2		467	1-22	21	16	H-2	2	4	49.882
1230	1	47	1020	2-21	158	287	E-3	35	64	876.797
	2		1109	2-21	172	255	B-3	18	20	608.294
1236	1	76	217	1-37	77	132	B-2	39	64	1262.017
	2		210	1-37	65	130	G-3	2	1	65.883
	3		155	2-9	14	17	A-2	13	12	216.315
	4		104	3-10	24	42	E-2	12	15	272.028
1242	1	33	555	2-40	73	180	D-3	2	8	186.278
	2		656	1-36	73	113	H-1	6	8	244.543

*No faders based on stereoscopic examination of SSU.

†Indicates regression estimate of the ground count (estimate made between photographic acquisition and ground visit).

Underlined primary sampling units (PSU) indicates plots randomly selected for disease data collections.

TABLE 1 - Concluded.

Photographic survey									Ground survey	
Stage 1			Stage 2			Stage 3				
Selected PSU number	Count	Quick counts	Total faders per PSU	Selected SSU number	Faders in selected SSU	Total faders per SSU	Selected TSU number	Faders in selected TSU	Ground counts	Volume, cu ft
1246	1	12	128	2-41	27	70	A-2	38	84	709.395
1248	1	5	90	4-40	8	3	G-1	3	4	81.889
	2		60	3-25	26	25	D-1	10	10	711.810
1266	1	28	33	2-14	12	26	C-2	13	22	296.515
	2		11	2-19	9	11	C-2	10	12	247.637
	3		37	2-19	6	9	C-2	8	12	247.637
1292	1	13	196	4-16	85	112	C-2	12	20	248.819
1312	1	16	212	4-26	61	74	H-2	38	160	1496.802
1318	1	32	292	1-10	74	163	C-3	20	29	464.152
1320	1	22	275	1-22	52	100	C-2	29	28	321.584
1328	1	32	234	4-16	50	78	E-1	10	15	296.251
1330	1	30	311	3-22	21	37	A-4	23	23	276.901
	2		363	2-14	37	54	F-1	11	13	236.437
	3		385	2-22	7	8	F-4	1	2†	0†
1334	1	9	150	4-30	27	46	C-4	15	4	33.097
1374	1	18	1282	4-12	80	117	G-4	5	4	26.121
	2		735	3-12	61	115	F-3	21	27	242.576
1386	1	17	395	4-38	24	139	F-4	45	106	861.253
1394	1	12	477	1-27	74	77	C-4	12	12	226.083
1408	1	11	123	2-27	12	10	B-1	3	6	81.031
1410	1	32	386	2-31	60	72	F-1	25	20	230.763
1416	1	22	328	1-34	22	24	A-3	13	19	117.821
	2		689	1-36	69	79	A-1	3	24	111.901
	3		358	2-37	18	27	E-2	3	6	91.534
1418	1	16	59	1-28	10	17	H-4	11	17	108.747
	2		90	1-27	22	28	C-3	1	5	41.808
1422	1	25	92	4-31	11	24	B-4	10	14	234.968
1462	1	6	127	3-19	38	45	G-2	10	20	98.736

*No faders based on stereoscopic examination of SSU.

†Indicates regression estimate of the ground count (estimate made between photographic acquisition and ground visit).

Underlined primary sampling units (PSU) indicates plots randomly selected for disease data collections.

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